ROYAL ASTRONOMICAL SOCIETY.

Vol. XVI. *December* 14, 1855. No. 2.

M. J. Johnson, Esq. President, in the Chair.

J. G. Barclay, Esq., 54 Lombard Street, and
William Monk, Esq., St. John's College, Cambridge,
were balloted for and duly elected Fellows of the Society.

Vol. XV. of the *Monthly Notices* has been recently published. Its price is fixed by the Council at *2s. 6d.* to Fellows of the Society, and *5s.* to the public. It need hardly be mentioned that this Journal offers a ready channel of publication to observers of all classes, and to every individual who devotes his attention more or less to astronomical pursuits.

Note on the Occultation of Stars by Saturn.
By the Astronomer Royal.

"In No. 920 of the *Astronomische Nachrichten* (1854, October 10) M. Winnecke pointed out the probability of the occultation of two stars, in the years 1854 and 1856 respectively, by *Saturn*.

"The first was the probable occultation of Lalande 9362, Bessel's Zone 343, on 1854, November 13, visible in Europe. Unfavourable weather prevented the observation of this phenomenon at Greenwich; I know not whether it was looked for in any other observatory.

"The second probable occultation is that of Lalande 13545, Bessel's Zone 279, on 1856, September 9, at about $8^h\ 20^m$ Berlin mean time. This occultation will not be visible in Europe. The positions of the Sun and *Saturn* at that time are nearly as follow:—

	h m		° ′
Sun's R.A ..	11 13	N.P.D. ..	84 57
Saturn's R.A.	6 53	N.P.D. ..	67 46

"The Sun is then west of the meridian of Greenwich by $7^h\ 29^m$, and *Saturn* is west of the same meridian by $11^h\ 49^m$.

"A great circle, drawn through the centre of the Sea of Okhotsk and passing a short distance east of the eastern coasts of Australia, defines the line on which the sun is rising. A great circle, passing a little to the west of Calcutta and a little to the west of the west-

ern coasts of Australia, defines the line on which *Saturn* is rising. Between these two great circles the phenomenon may be seen.

"The limits which I have indicated do not include Bombay or Madras. But they include Calcutta and every British settlement east of Calcutta; especially Singapore, the coasts of China, and the whole of Australia.

"Perhaps the circulation of this notice, in the monthly publication of the Society, may induce some persons to watch for a phenomenon which at any time would be highly worthy of attention; but which, in reference to discussions now pending, might be one of very great interest.

"1855, *Dec.* 10."

Observations of the Zodiacal Light at Highfield House Observatory, near Nottingham. By E. J. Lowe, F.R.A.S.

"The following are observations which I had intended forwarding to the Society some months ago; they form the continuation of several reports upon this subject, which I have before had the honour to communicate. The chief interesting feature is *an inner* line of *brighter light* seen on the 25th of February, 1854. It has struck me that this line may be the edge of a ring, and in this case the zodiacal light will be *a ring of light* surrounding the sun, so inclined as to be in the same (or nearly) plane with the zodiac. I am aware that several eminent astronomers have seen weighty reasons why this should not be the case, and I therefore refrain from entering further into the subject at the present moment, and shall content myself with giving merely the observations themselves.

Epoch 1854, February 26^d 7^h 30^m G.M.T.

became very brilliant by impulses. ♉ 28°, altitude 45°, considerably brighter than the galaxy. Last night there was a brisk breeze, to-night calm. The phenomenon was faint at 7 o'clock; was still brilliant at 8 o'clock, the pulsations being strongly marked, and less bright at 8^h 15^m.

Epoch 1854, February 18^d 7^h 30^m

visible for a few minutes, the axis passed midway between *α Arietis* and the *Pleiades*.

Epoch 1854, February 25^d 7^h 30^m

scarcely perceptible.

Epoch 1854, February 25^d 7^h 33^m

very brilliant.

Epoch 1854, February 25^d 7^h 35^m

faint.

Epoch 1854, February 25^{d} 7^{h} 45^{m}

time of greatest brilliancy. The pulsations of brightness more marked than I had ever before observed them, and at the times of maximum brightness, the phenomenon was altogether more brilliant than I had before seen it. The cone of light was *straight* along the northern edge, but decidedly *curved* on the southern edge.

Epoch 1854, February 25^{d} 8^{h} 0^{m}

The north edge cut the horizon 10° N. of W., and the south edge about 18° S. of W. If the N. edge were produced it would pass through *γ Piscium*. The axis cut the horizon 5° S. of W., the apex being at an altitude of 44°. The axis produced would pass 1° N. of the *Pleiades*.

Epoch 1854, February 25^{d} 7^{h} 45^{m} (continued).

At this time the position of the edges amongst the stars was noted. The cone passed S. of *γ Arietis* (but nearly touched that star at 7^{h} 40^{m}, and again at 8^{h} 0^{m}, yet only for a second or two). It mostly cut on the N. edge *η Piscium*, and on the S. edge *o Piscium;* at times both these stars were *within* the cone of light distances varying from 15′ to 30′. The stars *μ*, *ζ*, *ε*, and *δ Piscium* (within the cone) were scarcely visible, and occasionally invisible. There was a line of light, more brilliant than any other portion of the phenomenon, which extended along the whole length of the cone to within 5° of the apex, being brightest at about the altitude of *ε Piscium*.* The cone passed generally within 3° of *γ Pegasi*, yet occasionally within 1° of that star, whilst at times it was 4° distant from it. The zodiacal light was twice as brilliant as the brightest portions of the milky way; the latter, however, was not brilliant, although the night was very starlight. At 8^{h} 16^{m} a falling star, composed of a number of fragments, moved from *γ Pegasi* towards *ε Piscium*, and went out *exactly* as it touched the N. edge of the zodiacal light, leaving the impression that the phenomenon hid it from view; the meteor was only equal to a star of the fourth magnitude; stars of this magnitude were not visible *within* the cone of light.

Epoch 1854, March 1^{d} 7^{h} 30^{m}

faint, broader than on the 26th, yet more diffused, and the edges ill defined.

Epoch 1855, January 17^{d} 6^{h} 50^{m}

brilliant, and well defined near *Aquarius*. The N. edge cut *ζ Aquarii* and the S. edge *τ Aquarii;* the con ‹extended to the altitude of *α Andromedæ*, in the direction of the *Pleiades*.

Epoch 1855, February 12^{d} 7^{h} 0^{m}

magnificent; well marked on the edges; rose to about the altitude of *α Arietis*, pointing towards the *Pleiades*. The N. edge was 1° N. of *β Pegasi*.

* The author forwarded a sketch of the cone exhibiting the position of this line.—Editor.

Epoch 1855, February 14^d 7^h 0^m

faint and confused.

Epoch 1855, February 17^d 7^h 0^m

olerably bright, yet confused, owing to a strong auroral glare.

Epoch 1855, March 7^d 7^h 50^m

very brilliant, tolerably steady in its light; N. edge sharp and well defined, passing immediately over γ *Arietis*, and covering η *Piscium*. S. edge confused. The apex extended to ζ *Arietis*.

Epoch 1855, March 18^d 7^h 30^m

bright but confused.

Description of an Out-of-doors Equatoreal Stand for Telescopes.

By the Rev. Samuel King, M.A.

"The accompanying photograph will give a general idea of the construction of this instrument, which is a modification of the parallactic ladder described in Admiral Smyth's invaluable *Cycle*. The chief novelty is the introduction of circles of right ascension and declination divided on slate.

"Upon a pier of brick-work, built in cement upon a substantial foundation, is placed a stone cube, having its northern edge chamfered off at an angle equal to the co-latitude. On this sloping face is securely fixed the brass socket or collar (with antagonist screws for adjustment) which carries the south pivot of the polar axis. The collar for the north pivot is sunk in a square block of mahogany, having strong brass cylindrical trunnions horizontally situated on opposite sides, the axes of which are in a line with the collar. These trunnions work in sockets formed for them in the top of each leg of the supporting shears;—the collar is thus brought to bear true upon the shoulder of the pivot in any position of the legs while roughly adjusting for altitude.

"The polar axis is a strong, double mortised, oblong frame, within which, and acted upon by a small double tackle, slides another frame, like a sash-window, carrying the cradle or trough, with Y's at either end, in which the telescope is securely fixed, so that the lines of the polar and declination axes intersect in its centre of gravity, and it balances accurately in every position.

"On the foot of the polar axis is fixed the slate hour-circle, 15 inches in diameter, divided on the limb with considerable accuracy (by means of a lathe with division-plate and index) to four minutes of time, allowing a very fair estimate to half a minute (without a vernier, which I intend some time adding). The declination circle, also of slate, is 12 inches diameter, divided to 30′.

"This apparatus has been exposed to all the vicissitudes of the weather for more than a year and a half, without requiring any

material alteration in the adjustments. It carries an excellent telescope of 5 feet focal length and $4\frac{1}{4}$ inches aperture, by Mills of Pentonville; and with a power of 72 I can find, without fail, anything I look for by day or night. By means of a pulley-wheel beneath the hour-circle, connected by a catgut band with a smaller pulley acted upon by a tangent screw, I get an excellent slow motion in R.A., to which I hope shortly to attach a jack to act as a clock.

"The wood-work is of clean-grained Honduras mahogany. The cost of the whole to me was about 4*l.* The brass work and division of the circles, which I executed myself, I set down at 2*l.* additional. This is altogether a very small cost for the facilities which the apparatus affords to the astronomer whose means are limited; and there are few places now in which a suitable lathe, and a sufficiently skilful workman, cannot be found for the execution of all that is needed.

"I have been as concise as possible in the description of this affair; but it will give me much pleasure to furnish more particular details to any gentleman who may be desirous of them. It may be added that the framing of the shears being secured by brass thumb-screws, the whole machine may be taken to pieces and removed in five minutes, with the exception of the pier, which, with a little contrivance, might be made to answer the additional purpose of supporting a sun-dial.

"*St. Aubin's, Jersey, December* 18, 1855."

Occultations of Stars by the Moon observed at Highbury.
By T. W. Burr, Esq.

Latitude 51° 33′ 45″·1 N. Longitude 23″·8 W.

1855.			Sidereal Time. h m s	
March 5th γ *Virginis*	Preceding Star	Immersion	9 13 46·4	Bright Limb
,,	Following Star	,,	9 14 6·4	Bright Limb
,,	,,	Emersion	9 29 47·4	Dark Limb
April 23d λ *Cancri*		Immersion	12 57 59·8	Dark Limb
Oct. 24th *o Piscium* . . .		,,	23 56 54·6	Dark Limb. Moon very nearly full

"The two latter occultations are good observations as to time. In the case of γ *Virginis* the clock-error was not so accurately known; but the observations are recorded for the sake of drawing attention to the length of time during which the second star remained attached to the edge of the moon's disc. The preceding star disappeared instantaneously; but the following one, which arrived at the moon's edge in 4^s or 5^s, remained attached to it until 20^s had elapsed from the immersion of the first star, when the

second also disappeared. There was no projection of the star on the moon's surface; but it appeared to assume a planetary disc, part of which was hidden, and the rest remained as a slight excrescence on the moon's edge. Probably, had the immersion taken place at the dark limb, the whole of the spurious disc would have been seen projected on the surface, as the impression produced on my mind was that such was now the case, only the bright surfaces of the moon and star could not be distinguished from one another.

"In consequence of the moon's position being low in the east, the line joining the stars formed nearly a right angle with a tangent to the moon's disc; so that the longest possible time elapsed between the immersions: and the fact that the stars passed behind a very small portion of the moon's body, so that they might at first do little more than graze the edge, throws some light on the unusual period of time during which the attachment continued.

"The telescope was my equatoreal by Ross, 4 feet focal length, $3\frac{3}{8}$ inches aperture. Power, 173."

On the Dimensions of the Rings of Saturn.

By the Rev. R. Main, M.A.

The author commences by stating, that in the winter of 1852–3 he executed a series of measures of the dimensions of the rings of *Saturn*, with a double-image micrometer, similar in principle, but not identically the same, as that used in the measures which he executed in 1849 for determining the form of the planet, an account of which is published in vol. xviii. of the *Memoirs* of the Society. In the beginning of 1854 he repeated his measures of the dimensions of the rings. Both sets of measures will be found printed and reduced in the volumes of the *Greenwich Observations* for 1852 and 1854, which also contain an account of the construction of the micrometer, the method of using it, the degree of accuracy and delicacy of measurement attainable by it, and other circumstances which a critic would desire to become acquainted with.

The author, in giving a synopsis of the results of his measures as inserted in the *Greenwich Observations*, remarks, that he attaches no great weight to the measures of the breadth of the black division, on account of the extreme difficulty and uncertainty of the contacts of the point of reference with its borders. In fact, the aperture of the object-glass being only $6\frac{3}{4}$ inches, and only half of the light of the planet being employed for the formation of each image, all the measures were very difficult from the uncertainty of determining the exact contact of the assumed point of reference, namely, the extreme edge of the exterior bright ring, with the borders of the inner ring, and of the ball whose

dimensions were required. This difficulty was much increased by the confusion arising from the superposition of the different portions of one of the images upon the other, which obliged the author to deviate from the usual method of making contacts of images on opposite sides on account of its impracticability. He has consequently given in his synopsis of results only the position of the centre of the black division.

The author's measures for 1852–3 are included between December 30, 1852, and February 19, 1853. The following is the mean for January 11, 1853:—

Distance of assumed centre from	″
East exterior edge of outer ring	21·36
— centre of black division	19·19
— interior edge of inner bright ring	14·52
— edge of ball	8·79
West edge of ball	9·06
— interior edge of inner bright ring	14·50
— centre of black division	18·62
— exterior edge of outer ring	21·64

Or, assuming with M. Otto Struve that the centre of the ball of *Saturn* is coincident with that of the rings, we have, by taking the means of the measures on the east and west sides of the planet, the following results for 1853, January 11, when the log. distance of *Saturn* from the earth was 0·94267:—

Distance of centre of planet from	″
Edge of ball	8·98
Interior edge of inner bright ring	14·51
Centre of black division	18·91
Exterior edge of outer bright ring	21·50

Hence, subtracting the semi-diameter of the ball from the other quantities, and calling the distances of the edge of the ball from each of the other measured parts in order, according to M. Struve's notation, ad, ae',* and ag, we have,—

$$ad = 5''{\cdot}53 \qquad ae' = 9''{\cdot}93 \qquad ag = 12''{\cdot}52$$

Or, reducing these results to those which would have been observed at the mean distance of the planet 9·5389 (or log.$^{-1}$ 0·97950), assumed by M. Struve, the measures are,—

$$ad = 5''{\cdot}08 \qquad ae' = 9''{\cdot}12 \qquad ag = 11''{\cdot}50$$

---

* ae' is the mean of ae and af in M. Struve's figure.

The observations of 1854 extend from February 2 to March 17; the following is the mean value of the results for the epoch February 23, 1854:—

Distance of assumed centre from	″
East exterior edge of outer ring	20·62
— centre of black division	17·44
— interior edge of inner bright ring	13·75
— ball	8·01
West edge of ball	8·66
— interior edge of inner bright ring	14·27
— centre of black division	18·29
— exterior edge of outer ring	20·59

The means of the measures given above correspond to the log. distance of the planet 0·96236, and at this distance we have, therefore (taking the means on each side of the centre as before),—

Distance of centre of planet from	
Edge of ball =	″8·34 (semi-diameter of ball)
Interior edge of inner bright ring =	14·01
Centre of black division =	17·87
Exterior edge of outer bright ring =	20·61

Hence, at this distance, $ad = 5''{\cdot}67$, $ae' = 9''{\cdot}53$, $ag = 12''{\cdot}27$. And at the mean distance of the planet, 9·5389,—

$$ad = 5''{\cdot}46 \qquad ae' = 9''{\cdot}17 \qquad ag = 11''{\cdot}81$$

Hence the general results of the measures, compared with the measures of M. Struve, are the following:—

	Main. 1852–3.	Main. 1854.	Struve.
	″	″	″
ad =	5·08	5·46	3·65
ae' =	9·12	9·17	8·52
ag =	11·50	11·07	11·07

Or, taking the mean of the two sets of measures, since they have on the whole pretty nearly equal weights,—

	Main. 1852–3.	Struve. 1854.	M–S.
	″	″	″
ad =	5·27	3·65	+ 1·62
ae' =	9·15	8·52	+ 0·63
=	11·28	11·07	+ 0·21

With regard to these results, the author remarks that the differences increase rapidly on approaching towards the limb of the ball from which they are reckoned, and seem to indicate that, either by M. Otto Struve or by himself, large arcs are measured on a different scale from small ones.

The author remarks that, so far as his measures can be depended on, they do not give any support to the hypothesis of Otto Struve, concerning the gradual diminution of the interval between the ball of the planet and the inner edge of the interior bright ring; and if there were no discrepancies in the measures which made him diffident of presenting them to astronomers as capable of settling a point of so much delicacy, he should be fully satisfied that M. Struve's idea was not yet sufficiently proved. He was fully convinced, however, of the uncertainty of many of the individual measures from the confusion of the images, and of their consequent inferiority to those made for the determination of the form of the planet in 1849, and also to the measures for determining the length and breadth of the exterior edge of the outer ring. But what more especially impressed him with the necessity of receiving the results with caution, was the circumstance that the final measure for the ball of the planet is considerably smaller than that which he deduced in 1849, and which agrees with the value generally adopted by astronomers.

Taking the means of the east and west semi-diameters of the ball as measured in 1852–53, and reducing them to the mean distance assumed by M. Otto Struve, namely, 9·5389, the author obtains 8″·20 for the final value of the semi-diameter of the ball.

Treating the measures of 1854 in the same way, he finds the resulting value of the semi-diameter to be 8″·02. He remarks that the agreement between this result and that deduced from the measures of 1852–3, is sufficiently close to show that they are a fair representation of observations of the ball made by his own eye with the double-image micrometer, and in the manner previously explained when the ball was seen surrounded by his ring. The mean of the two results above mentioned (8″·20 and 8″·02), when compared with the corresponding value of the semi-diameter deduced by him in 1849, namely, 8″·75, indicates a difference of no less than 0″·64; a quantity certainly too great to be the result of accident, and undoubtedly attributable to the different circumstances under which the measures were made. M. Struve's value of the semi-diameter of the ball is 8″·80, a result agreeing almost exactly with that deduced by the author in 1849.

The author next proceeds to give his measures of the extreme length and breadth of the exterior edge of the outer ring. He remarks that these measures are much superior in accuracy to the others, the outer edges of the system of rings presenting no impediment to the ordinary use of the double-image micrometer. The mean of the measures made in 1852–3 gives 39″·67 for the diameter of the exterior ring; the mean of the measures made in

1854 gives 39″·76; consequently the mean of the entire collection of measures is 39″·72.

The author also deduces from the measures of the minor axis of the exterior ring the corresponding values of the major axis, by taking into account the elevation of the earth above the plane of the ring. The mean value of the diameter of the ring thus found is 39″·75, agreeing almost exactly with that determined by direct observation. This result the author considers to be definitive, and comparable with the value of the semi-diameter of the ball obtained by him in 1849.

Having thus given the general results of the measures of the rings, the author proceeds to examine the ratio which the dark space intervening between the inner bright ring and the planet bears to the breadth of the bright rings. It has been mentioned that he found the breadth of the dark space to be 5″·27, and that of the bright rings to be 6″·01; consequently the ratio of the two quantities is 0·87. On the other hand, M. Otto Struve found the breadth of the dark space to be 3″·65, and that of the rings 7″·42, which give a ratio of only 0·49.

The difference between the values of the ratio thus found being too great to be passed over without any attempt at explanation, the author proceeds to substantiate his own measures by other considerations. He had already alluded to the difficulty of making accurate contacts for the interior edge of the inner ring and the ball, on account of the confusion of the images. The difficulty was very much greater when the object of reference was beyond the centre than when it was near the outer edge of the system of rings, and the measures would consequently be less accurate. From fresh trials, which he made during the present opposition of the planet (December 1855), he felt convinced that at the *entering* side of the point of reference the measures can be made with confidence, but cannot be executed so unexceptionably on the other side. He therefore discusses the two sets of measures separately.

The measures of 1852–3 give him 0·95 for the ratio of the dark space to the breadth of the rings; the measures of 1854 indicate the same ratio to be 0·97. A curious circumstance, however, connected with both sets of measures, is this,—in several instances the breadth of the bright rings is conspicuously less than the dark interval, and the difference between them steadily decreases till the two are equal; then the breadth of ring becomes greater than the dark interval, and their ratio steadily increases. This curious law, developed equally well in both sets of observations, can scarcely be the result of accident. It probably depends on the change of optical appearance of the planet during the period of observation, and perhaps in some degree, also, on the training of the eye of the observer during the time. The author adds, however, that it would be a very bold assumption if, on the strength of these observations, which are incomparably better than the early observations on which M. Struve rests his

theory, we were to conclude that the system of *Saturn* really underwent periodical changes of the magnitude thus indicated.

The author was fortunately enabled to avail himself of some favourable evenings during the present opposition (December 1855) to make an extensive series of observations, with direct reference to the relation of the breadth of the system of bright rings to that of the dark interval.

A numerous series of measures, executed on the evening of the 5th of December, gave him 1·08 for the ratio of the dark space to the breadth of ring; a similar series of measures, executed on the 6th, gave him 1·11 for the value of the same ratio. It has been mentioned that the values of the semi-diameter of the planet which the author obtained from his recent observations, are sensibly smaller than the value of the same element which he deduced in 1849, during the disappearance of the ring. He remarks that this probably arises from the glare of the ring, which prevents the true border of the planet being observed. The circumstance at all events suggests a correction which must be applied to the observed values of the dark space between the planet and the bright rings. The author here appends a table, by which he shows that the application of this correction causes the disappearance of the curious anomaly in the ratios between the values of the dark space and the breadth of the rings. The following are the final results deduced by him from the observations of 1852–3,—

$$\frac{\text{Corrected breadth of dark space}}{\text{Breadth of rings}} = 0{\cdot}838$$

and from the observations of 1854,—

$$\frac{\text{Corrected breadth of dark space}}{\text{Breadth of rings}} = 0{\cdot}844$$

The agreement of these results leaves nothing to be desired. We have then the following definitive values for the mean distance of the planet from the earth previously assumed,—

Diameter of exterior edge of outer ring = 39″·73
Diameter of inner edge of inner ring = 27·65
Equatoreal diameter of ball = 17·50

The author next examines the question relative to the dimensions of the black division. His final conclusion is, that the diameter of the circle coinciding with the centre of the division amounts to 36″·15.

He remarks, that there is still one circumstance connected with the observations of the planet which does not at present admit of explanation. Each of the results of the present year is quite equal in weight to either of the results deduced from the totality of the observations of 1853 and 1854; the two results agree

with each other with all desirable accuracy ; and yet the ratios indicated by them are very much greater than those of 1853 and 1854. He adds, that it would be useless to speculate at present upon the cause of this discordance ; but he looks forward with interest to the observations which he hopes to make at the present opposition in the expectation of obtaining some solution of the difficulty. He concludes with the following remarks :—

"For the present, I can only express my opinion that the results which are given exhibit with tolerable accuracy the dimensions of the *Saturnian* system, and that no change whatever has taken place in the system since the time of Huygens. If this opinion be correct, it will follow that M. Struve's measures of the breadth of the dark space between the bright rings and the ball have been influenced by some circumstance which has not affected the distance between the ball and the outer edge of the outer ring, for in this latter particular my measures are almost coincident with his. Under these circumstances there is little doubt that M. Struve will be anxious to seize the favourable opportunity that presents itself at the present opposition of the planet for repeating his measures in a way that will prevent the possibility of doubt ; and I may at the same time direct the attention of such English astronomers as are furnished with good telescopes equatoreally mounted to the interesting circumstances which I have attempted in the present memoir to elucidate."

On the Attraction of the Himalaya Mountains and of the elevated Regions beyond them, upon the Plumb-line in India. By the Venerable John Henry Pratt, M.A., Archdeacon of Calcutta.*

The author of this paper commences by remarking that the results of the measurement of the great arc of the meridian of India afford undoubted indications of the disturbing influence exercised upon the direction of the plumb-line by the attraction of the Himalaya Mountains and the elevated regions lying beyond them. Thus, the amplitude of the northern division of the arc included between Kaliana and Kalianpur, when determined by astronomical observations of latitude at the two extreme stations, was found to be $5^\circ\ 23'\ 37''{\cdot}058$; whereas, when computed geodetically, assuming the usually admitted values of the major axis and ellipticity of the earth, the value of the amplitude appeared to be $5^\circ\ 23'\ 42''{\cdot}294$. The circumstance of the astronomical arc being in *defect* as compared with the geodetical arc, is favourable to the supposition of the discordance being due to the attraction of the mountainous country situate to the north of the arc ; for the ten-

* Phil. Trans., 1855, p. 53, *et seq.*

dency of the disturbing attraction in such a case would manifestly be to produce a greater deviation of the plumb-line at the northern than at the southern extremity of the arc, and thereby to diminish the astronomical determination of the amplitude of the arc somewhat below its true value. The question, however, arises, is the *quantity* of this discordance, namely, 5″·236, the same as that which would be occasioned by the disturbing influence exercised upon the direction of the plumb-line at the two stations? The author has mainly devoted his paper to the discussion of this important point.

The geodetical operations cannot be considered as wholly exempt from the influence of mountain attraction, seeing that in determining the elevations and depressions of the stations of the various triangles, the direction of the plumb-line must be taken into account. The author, however, has shown (what indeed could scarcely have required demonstration) that in consequence of the smallness of the elevations and depressions the effect thus produced is utterly insensible. He next investigates the effect which a small error in the amplitude of an arc would produce on the value of the ellipticity; and he finds, that by assuming the ellipticity to be $\frac{1}{300}$, an error in defect of 5″·236 in the amplitude would, under the most favourable circumstances, diminish the ellipticity by $\frac{1}{25}$th of its whole value. It is not, therefore, sufficient to attribute the discordance to the influence of mountain attraction; but, on the contrary, it becomes an object of the highest importance to ascertain whether the effects due to this cause are capable of accounting exactly for the observed anomaly.

In order to calculate the attraction at any station, A, of the superincumbent matter contained on the earth's surface, the author supposes a series of vertical planes to be drawn through A, making any angles with each other, and dividing the surface through A parallel to the sea-level, into a number of *lunes*, all meeting again in a point at the antipodes of A. He then draws a series of concentric circles upon this surface, having A for their common centre, the distance between two consecutive circles being regulated by a fixed law. In this way he divides the whole surface into a number of four-sided *compartments*, two of the sides in every compartment converging to A, and the other two being parts of circles concentric with respect to A.

Supposing β to be the angle contained between any two vertical planes passing through A, and which consequently measures the breadth of the lune formed by them; α and $\alpha + \varphi$, the angular distances from A of any compartment in this lune; ϱ, the mean density of the earth; and h, the average height of the earth's surface above the level of the compartment; the author finds the attraction upon A of the whole mass standing on the compartment to be

$$= \varrho \sin \tfrac{1}{2}\beta \cdot \frac{\varphi \cos^2 (\frac{1}{2}\alpha + \frac{1}{4}\varphi)}{\sin\ (\frac{1}{2}\alpha + \frac{1}{4}\varphi)} \cdot h$$

This expression is simplified by supposing the relation between α and φ to be such that

$$\frac{\varphi \cos^2(\frac{1}{2}\alpha + \frac{1}{4}\varphi)}{\sin(\frac{1}{2}\alpha + \frac{1}{4}\varphi)} = \text{a numerical constant} = c$$

The value of c being determined by making $\varphi = \frac{1}{10}\alpha$, φ and α being both supposed indefinitely small, the relation between φ and α is reduced to the following form:

$$\frac{\varphi \cos^2(\frac{1}{2}\alpha + \frac{1}{4}\varphi)}{\sin(\frac{1}{2}\alpha + \frac{1}{4}\varphi)} = \frac{4}{21}$$

whence attraction of mass standing on any compartment

$$= \frac{4}{21}\varrho \sin\tfrac{1}{2}\beta \,.\, h$$

This expression depends upon h, the average height of the surface of the mass, above the surface through A, and not at all upon the distance of the compartment from A.

The equation between φ and α obviously fixes the relation between the distances from A of any two consecutive circles, the arcs of which form the sides of the compartments; or, in other words, the relation between the length of any compartment and its distance from A. The author calls this relation the *Law of Dissection.*

It will be seen that the expression for calculating the attraction of the matter above the surface passing through A is reduced to a formula of extreme simplicity. It only remains to calculate the distances from A by means of the Law of Dissection, and lay down the circles and lines diverging from A upon a good map on which the elevations and depressions are marked, and the attractions of the several masses standing on the compartments thus marked out will be given by the formula for the attraction as soon as their average elevations have been determined.

Assuming the mean density of the earth to be 5·66 times the density of distilled water as determined by Baily, and supposing the density of the superficial crust of the earth to be = 2·75, which is the density assigned to the mountain Schehallien, the author finds the deflection of the plumb-line caused by the mass standing on any one compartment to be

$$= 1''\cdot1392 \sin\tfrac{1}{2}\beta \,.\, h$$

The equation between φ and α involving the Law of Dissection, not admitting of a direct solution, the author employs an ingenious process by which he is enabled to effect this object with all desirable accuracy, and hence he derives the lengths of the compartments and their respective distances from A. These distances being laid down and the concentric circles drawn upon a map or globe, it only remains to ascertain the average heights of the masses standing on the compartments thus drawn. The author

suggests some practical methods for effecting this object, and concludes the exposition of his method of computation with the following remark:—

"It will be evident that mountain ranges will assume a less importance in this calculation as they are more distant from A, since they will stand on a larger compartment; and therefore, when in imagination levelled down to cover the whole compartment, and give the average height, they will stand at a much less altitude. It is for this reason that a knowledge of extensive table-lands of considerable elevation, and of the elevated channels of rivers is of far more importance in this part of the calculation, especially in the remoter parts, than of mountain-peaks and mountain-ridges."

The author next investigates an approximate value of the intensity of mountain attraction at the two extremities and the middle station of the arc. The extreme stations are Kaliana, in latitude 29° 30′ 48″ and Damargida, in latitude 18° 3′ 15″; the middle station is Kalianpur, in latitude 24° 7′ 11″. The northern, middle, and southern stations are denominated by him respectively A, B, and C.

He first traces out upon a map the tract of country which he supposes to exercise a sensible influence upon the direction of the plumb-line in India. This he calls the *Enclosed Space*. Before describing the geographical features of this region, he shows, by reference to Humboldt's *Aspects of Nature* and other authorities, that the attraction of the countries situate externally with respect to it cannot sensibly affect the direction of the plumb-line at any station of the great arc of India. He then divides the Enclosed Space into two regions, which he denominates respectively the *Known Region* and the *Doubtful Region*. The general features of the Known Region are gathered from the Survey and other maps of India. With respect to the Doubtful Region the author is compelled to rely upon the statements of Humboldt and other travellers. Having divided the Enclosed Space into a number of four-sided compartments by drawing a series of lines and concentric circles corresponding to each of the three stations, in accordance with the method of computation which he had already explained, he endeavours to determine the average height on each compartment by means of the knowledge thus derived respecting its geographical features. The computation of the attraction at each station was then effected with great facility. The following are the final results at which he arrived:—

Deflection of plumb-line in	meridian	at A ..	27″·853
,,	,,	at B ..	11·968
,,	,,	at C ..	6·909
,,	in prime vertical	at A ..	16·942
,,	,,	at B ..	4·763
,,	,,	at C ..	2·723

Hence we obtain

Difference of Meridian Deflections at A and B	..	15″·885
,, ,,	at A and C ..	20·944
,, ,,	at B and C ..	5·059

The first of these quantities is considerably greater than 5″·236, the quantity brought to light by the *India Survey;* and the values of the deflections at B and C bear a far higher ratio to those at A than has been generally supposed. The following are the results for the total deflection at each of the stations:—

Total Deflection at A	..	32″·601,	and in Azimuth,	31° 18′ east.
,, ,, B	..	12·880	,,	21 42 ,,
,, ,, C	..	7·426	,,	21 31 ,,

The author next makes various suppositions for reducing the computed deflection so as to make it agree more nearly with the results of observation. His original assumption was that the density of the elevated region is 2·75 times the density of distilled water, which was the estimated density of the mountain of Schehallien. His opinion is that this assumption is not too great, since a large share of the deflection is produced by the attraction of the elevated plateau which lies in Thibet and south of that country; and as this is on an average 10,000 feet or more high, the lower part of the materials must be denser rather than lighter than those of a mountain of inconsiderable altitude. "If, however," continues the author, "we do reduce the density, say to 2·25, which is yielding much, still the deflections and their differences are reduced by only one-fifth part, and therefore this will not solve the difficulty."

The author next has recourse to an hypothesis which is tantamount to supposing the whole mass on the Doubtful Region to be non-existent; but even in this case the difference of deflection at A and B is not reduced below 9″·753, which is greater than 5″·236 in the ratio of 13 to 7. Nor will the attraction be sufficiently diminished if the density of the remaining mass on the Known Region be reduced.

A third means of reduction founded upon the supposition of the non-existence of the mass on the Doubtful Region, and a diminution of the altitude of the mass on the Known Region is found to be equally ineffectual in reconciling the computed with the observed deflection.

By calculation the author finds

$$\frac{\text{Mass on Doubtful Region}}{\text{Mass on Known Region}} = 6{\cdot}264$$

or the mass on the Doubtful Region is greater than that on the Known Region in a ratio higher than 25 to 4. Also,

$$\frac{\text{Mass on whole Enclosed Space}}{\text{Mass of the Earth}} = 0{\cdot}00002825\text{7}$$

The author next computes for each station the point at which the whole of the elevated mass would require to be concentrated in order that it might produce the same amount of deflection. In this manner he finds the

	Miles.
Distance from A of point of concentration	= 1688
.. B	= 2692
.. C	= 3544

The differences of these two last from the first is far greater than the distance of B and C from A, viz. 5° 23′ 37″ and 11° 27′ 33″. From this it is easily inferred, what indeed did not need this proof, that the mass in no sense whatever, even an approximate one, attracts as if concentrated in a fixed point.

Assuming that the heights of the elevated region have been rightly assigned in his paper, the author finds by a comparison of the northern and southern divisions of the Indian arc, that its ellipticity amounts to $\frac{1}{426{\cdot}2}$, a result which shows that the arc is more curved than it would be if it had the mean ellipticity. The author illustrates the increased curvature by comparing the height of the middle point of the arc above the chord with the height of the same point furnished by the mean ellipticity ($\frac{1}{300}$) and by the ellipticity which has been deduced from the Indian arc without taking into account the effect of mountain attraction, viz. $\frac{1}{196{\cdot}3}$. In this way he finds

	Miles.
For the mean ellipticity, height =	19·8992
Ellipticity $\frac{1}{426{\cdot}2}$	19·9290
.. $\frac{1}{196{\cdot}3}$	19·8460

"The ellipticity, therefore," says the author, "which results from taking account of mountain attraction raises the middle point of the arc by 0·0298 of a mile, or 157 feet; whereas the ellipticity, when mountain attraction is neglected, depresses the arc through 0·0532 of a mile, or 281 feet. These quantities are nearly in the ratio of 5 to 9. Hence the consideration given to mountain attraction in this paper brings the curvature of the Indian arc nearer the mean curvature than the neglect of mountain attraction does in the ratio of 5 to 9. This is, as far as it goes, in favour of these calculations.

Deep River, Cape of Good Hope,
July 12, 1854."

On the Computation of the Effect of the Attraction of Mountain Masses as disturbing the Apparent Astronomical Latitude of Stations in Geodetic Surveys. By G. B. Airy, Esq., Astronomer Royal.*

In this short paper the author considered the conclusion to which Archdeacon Pratt was conducted by his investigation of the effects of mountain attraction on the direction of the plumb-line in India. He remarks that not only is there nothing surprising in the discordance between the observed and computed deflections, but that it ought to have been anticipated, and that, instead of expecting a positive effect of attraction of a large mountain mass upon a station at a considerable distance from it, we ought to be prepared to expect no effect whatever, or in some cases even a small negative effect.

For the purpose of illustrating his views the author supposes the crust of the earth to be ten miles thick, and to be of less density than the fluid in the interior, which for convenience of designation he calls *lava*. Supposing a mass of table-land to rest upon the earth's surface, the breadth of which mass in its smaller horizontal dimension is 100 miles, and the height two miles, the author maintains that the permanent existence of such a state of things is not possible in nature, for the weight of the table-land would break the crust through its whole depth from the top of the table-land to the surface of the lava, and either the whole or only the middle part would sink into the lava. He proceeds to prove this by showing that the cohesion which would be necessary to prevent the table-land from breaking the crust would be capable of supporting a hanging column of rock twenty miles long, a conclusion which is contrary to all experience. Other suppositions with respect to the thickness of the crust are shown to lead to conclusions equally inadmissible.

The author is of opinion that there can be no other support to the table-land than that arising from the downward projection of a portion of the earth's light crust into the dense lava. He conceives, in fact, that the state of the earth's crust lying upon the lava may be compared with perfect correctness to the state of a raft of timber floating upon water, in which, if we remark one log whose upper surface floats much higher than the upper surfaces of the others, we are certain that its lower surface lies deeper in the water than the lower surfaces of the others. According to this view of the subject the disturbing influence will depend on the positive attraction produced by the elevated table-land and the negative attraction produced by the substitution of a certain volume of light crust for heavy lava.

The general conclusion at which the author arrives is this: in all cases the real disturbance will be less than that found by com-

* Phil. Trans., 1855, p. 101, *et seq.*

puting the effect of the mountains, on the law of gravitation. Near to the elevated country the part which is to be subtracted from the computed effect is a small proportion of the whole. At a distance from the elevated country the part which is to be subtracted is so nearly equal to the whole that the remainder may be neglected as insignificant, even in cases where the attraction of the elevated country itself would be considerable. But in our ignorance of the depth at which the downward immersion of the projecting crust into the lava takes place, we cannot give greater precision to the statement.

The author finally remarks that the condition of *breakage* of the table-lands which pervades his reasoning is not applicable to such elevations as Schehallien, but to high tracts of very great horizontal extent, such as those to the north of India.

Measurements of Saturn made with the Astronomer Royal's Double-Image Micrometer employed with a Thirteen-inch Newtonian Equatoreal. By Warren De la Rue, Esq.

			Reduced to M.D. 9·5430
Outer diameter of Outer Ring,	Oct. 30, 1854	45″·913	39″·63
„ „	Dec. 3,	47·226	39·83
„ „	10,	47·811	40·35
„ „	Dec. 23, 1855	46·970	39·53
		Mean	39·83
Inner diameter of Outer Ring,	Oct. 30, 1854	41″·345	35″·69
„ „	Dec. 3,	41·629	35·11
„ „	10,	11·700	35·20
		Mean	35·33
Outer diameter of Middle Ring,	Dec. 3, 1854	39″·352	33″·19
„ „	10,	39·950	33·72
		Mean	33·45
Inner diameter of Middle Ring,	Dec. 3, 1854	31″·03	26″·17
„ „	18, 1855	32·87	27·65
		Mean	26·91
Equatoreal diameter of Planet,	Dec. 3, 1854	20″·967	17″·66

Each of the measures given is the mean of at least six readings of the micrometer, the contacts being made alternately on opposite sides. One revolution of the micrometer being equal to 8″·018, except with the lens employed on Dec. 10, 1854, when one revolution was equal to 4″·4001.

After the conclusion of the ordinary business of the meeting, Mr. Main gave a verbal account, illustrated by drawings, of the substance of his paper communicated to the Society on the *Dimensions of the Rings of Saturn.*

The drawings were intended to exhibit to the eye the appearance of the Saturnian system according to the various estimations of the observers who had chiefly devoted themselves to the scrutiny of the planet, namely, M. Encke, Mr. De la Rue, Capt. Jacob, Mr. Main, and M. Otto Struve, for the purpose of enabling the members of the Society, who were furnished with good telescopes, and who had been in the habit of viewing *Saturn*, to judge of the probable fidelity of the different estimations. Of these representations Mr. Main's was that which gave the largest measure of the dark interval between the body of the planet and the inner edge of the interior bright ring, while M. Otto Struve's representation gave by far the smallest value. Mr. Main drew attention to this fact, that the measures of M. Otto Struve were substantiated by those of no modern or contemporaneous observer, and were totally at variance with all the ancient observations, and consequently that the natural inference was, that some unusual circumstance had affected his estimations. He also showed that if M. Otto Struve's results were neglected, there would be no ground whatever for his theory respecting the approximation of the rings towards the body of the planet. In connexion with this part of the subject, Mr. Main drew attention to a Dutch pamphlet recently written by Professor Kaiser of Leyden,* in which, by considerable research, new light was thrown upon the observations of Huygens, and, at least during the lifetime of that observer, the inferences drawn by M. Otto Struve were found, by additional observations of Huygens, to be contradicted.

Mr. Main then drew attention to a fact connected with his own measures, as showing the delicate nature of such inquiries, and the singular errors to which the measurers are liable. In the early portion of the measures of 1853, for instance, the measured breadth of the dark space was larger than the breadth of the system of bright rings; this difference between them decreased continually and systematically till the two appeared to be equal, after which the breadth of the dark rings became increasingly larger than the dark space. This difficulty was ultimately cleared up by a comparison of the values of the diameter of the ball of the planet obtained in this series of measures, with Mr. Main's own standard value given in his paper on the *Form of the Planet Saturn*, by which it appeared that the excess of the standard above the measured values decreased continually, and that when these excesses were applied negatively, as corrections to the mea-

* Professor Kaiser has recently informed the Editor, in reply to a communication respecting this paper, that it is also published in vol. iii. of the *Proceedings of the Royal Academy of Sciences of Amsterdam.* An account of it will be given in a future number of the *Notices*.—R. G.

sured breadths of the dark space, the anomaly entirely disappeared.

In confirmation of Mr. Main's measures, he stated that he had received from the President, Mr. Johnson, some very recently-made measures, kindly undertaken at his request, which agree very closely with his own; and the announcement of this agreement elicited from the members present an expression of approbation.

A conversation on the subject afterwards followed, in which the President, the Astronomer Royal, Mr. Hind, and Mr. De la Rue took part, and the general correctness of Mr. Main's conclusions seemed to be acquiesced in by all those gentlemen.

Elements of Atalanta. By M. Bruhns.

Epoch 1855, Nov. 0. Berlin M.T.

		°	′	″
M	....	341	22	48·1
π	....	40	42	12·7
Ω	....	359	0	8·8
i	....	19	6	45·2
φ	....	17	5	3·5
μ	....		769″·261	
Log. a	....		0·442621	

These elements are calculated from the following three Berlin observations:

		M.T. Berlin. h m s	R.A. ° ′ ″	Decl. ° ′ ″
1855. Oct.	12 ..	10 33 3·9 ..	343 50 32·0 ..	6 48 49
	17 ..	9 46 31·4 ..	343 1 43·8 ..	6 3 15·6
	23 ..	7 4 27·4 ..	342 21 43·8 ..	5 6 16·4

Observations of Comet III. 1855, *taken with the* $8\frac{1}{2}$*-inch Refractor of the Liverpool Observatory.* By John Hartnup, Esq.

	G.M.T.	Comet's R.A.	Log. $\frac{p}{P}$	N.P.D.	Log. $\frac{q}{P}$
1855.	h m s	h m s		° ′ ″	
Dec 2	11 57 9·5	7 4 11·13	−8·395	86 24 55·2	−9·8856
2	12 54 1·0	7 3 10·76	−8·210	86 24 19·7	−9·8828

Star of Comparison, Procyon.

Assumed mean place for Jan. 0, 1855.

$7^h\ 31^m\ 42^s{\cdot}51$ R.A. $84^c\ 24'\ 24''{\cdot}45$ N.P.D.

M. Brorsen has communicated to the *Astronomische Nachrichten* the following note respecting the phenomenon accompanying the zodiacal light, alluded to in the *Monthly Notices* for November:—

"I have observed this phenomenon here, and also upon the island of Alsen in the duchy of Schleswig, during the last two years, and have given a detailed account of it in Dr. Jahn's *Weekly Conversations on Astronomy* for 1854. The observations, which essentially agree in both years, are the following:—The phenomenon is seen, not only about the time of the vernal equinox, but also during the period of the autumnal equinox, although undoubtedly it is more conspicuous in the earlier season of the year. The first faint traces of it are perceived in the month of February. It continues to increase in brightness and extent throughout the months of March, April, and the beginning of May. The fainter and less considerable phenomenon of autumn is visible during the months of September, October, and November. With respect to both phenomena, I have convinced myself by repeated observations, that the brightest part lies exactly opposite to the sun, so that the estimated point of most intense light falls decidedly within a degree of the point which is in opposition to the sun. The observations further indicate, that the phenomenon of spring connects itself with the western zodiacal light towards the middle of April by a faint streak of light, gradually increasing in brightness, which was not previously visible. But the phenomenon of autumn appears in the first half of November to extend along the ecliptic as far as the western horizon in the shape of a very faint and previously invisible zone of light, which gradually increases in brightness and in the breadth of its base, until at length it assumes the well-known aspect of the winter evening zodiacal light. From this time, however, till the beginning of March, its extremity remains almost stationary about the region of τ_1 and τ_2 *Arietis*. Both phenomena can be seen here distinctly every evening at the same season of the year, when the sky is clear, and the observed position of the heavens is moderately high; nay, they are even visible at the commencement of moonlight.

"*Senftenberg, Nov.* 13, 1855."

At the meeting of the Society there was exhibited a series of beautiful photographs of the moon, which were executed with the great refractor of the Cambridge Observatory, U.S.

Mr. A. F. M'Intosh has forwarded a paper on *Saturn's* rings. He supposes that these appendages originally consisted of separate streams of a fluid substance circulating around the sun in the vicinity of *Saturn's* orbit; that the planet's attraction converted them into rings about himself; and that the number of rings is owing to the number of separate streams of matter. The author has entered into various speculations in support of his views, but it would be unnecessary to make any further allusion to them here.

Tafeln der Flora mit Berücksichtigung der Störungen durch Jupiter und Saturn entworfen von F. Brünnow, Dr., Director der Sternwarte zu Ann-Arbor in Michigan. Berlin, 1855.

These Tables of *Flora* are constructed by Dr. Brünnow according to a theory of general perturbations devised by Professor Encke. An account of this theory is given by Professor Encke in a letter to the Astronomer Royal, which is published in the *Monthly Notices* for May 1853. The mean elliptic elements of the planet having been deduced from a series of observations extending only over four years, it cannot be expected that the Tables will be capable of representing the motion of the planet with anything more than an approximate degree of accuracy beyond a limited period of time. The author, however, expresses a confident hope, that at some future epoch, when an extensive series of oppositions of the planet shall have been obtained, the mean elliptic elements may be deduced by the aid of the Tables with such accuracy, that when the perturbations have been strictly computed, new tables of the planet may be constructed, which shall satisfy the wants of the astronomer for a long period of time—perhaps for hundreds of years.

A gentleman engaged in astronomical pursuits is desirous of purchasing a second-hand transit-instrument of modern construction possessing something like the following requirements:—Size, 2 or $2\frac{1}{2}$ feet; aperture of object-glass, not less than $2\frac{1}{2}$ inches; portable iron stand; maker, Troughton and Simms, or Dollond; furnished with one or more moveable wire-micrometers. For further information apply at the Apartments of the Society.

CONTENTS.

	Page
Fellows elected	25
Announcement respecting *Monthly Notices*	ib.
Note on the Occultation of Stars by the Planet *Saturn*, by the Astronomer Royal	ib.
Observations on the Zodiacal Light, by Mr. Lowe	26
Description of an Out-of-doors Equatoreal Stand for Telescopes, by the Rev. Samuel King..	28
Occultations of Stars by the Moon, by Mr. Burr	29
On the Dimensions of the Rings of *Saturn*, by the Rev. R. Main	30
On the Attraction of the Himalaya Mountains, by Archdeacon Pratt ..	36
On the Computation of the Attraction of Mountain Masses, by the Astronomer Royal	42
Measures of *Saturn*, by Mr. De la Rue	43
Additional Remarks on *Saturn's* Rings, by Rev. R. Main	44
Elements of *Atalanta*, by M. Bruhns	45
Observations of Comet III. by Mr. Hartnup	ib.
On a Phenomenon accompanying the Zodiacal Light, by M. Brorsen ..	46
Tables of *Flora*, by Dr. Brünnow	47
Miscellaneous	ib.

London :—Printed by G. Barclay, Castle St. Leicester Sq.